Scattering Solar Thermal Concentrators

Penn State University

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PROJECT OBJECTIVES

Goal:

- Concentrate sunlight without mirror movement
  - eliminate tracking error due to wind-loading
  - improved reliability due to fewer moving parts
  - fixed heat transfer elements → simplify design and increase reliability.

Innovation:

- Novel approach to concentrate sunlight
- Just within last 3 months, several relevant reports published:
  - Distributed, lenslet scattering concentration[1]
  - Self-adaptive, optically-induced scattering responses aimed at scattering concentration[2,3,4]

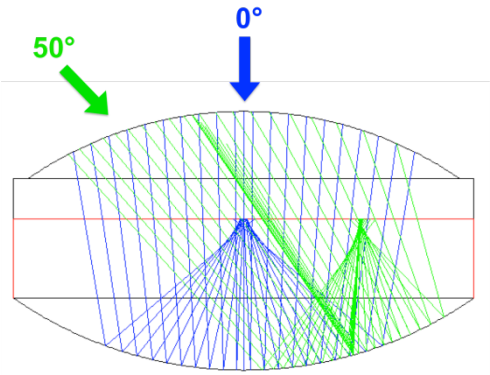
Milestones:

- Simulation and optimization of collection optic, toward first milestone performance targets

[1]J.M. Hallas et. al. *Appl. Optics* **51**, 6117 (2012)

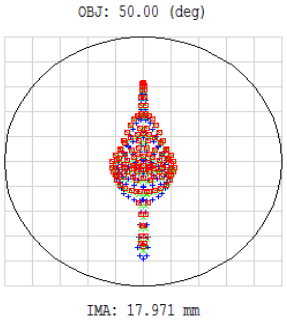
APPROACH

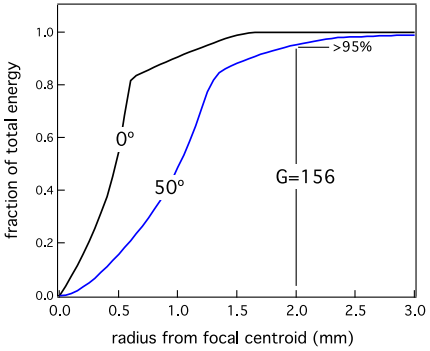
- Rigorous ray tracing simulation in Zemax for design of collection optic
- Fabricate and test index-matching elastomers via:
  - spectrophotometry
  - spectroscopic ellipsometry
- Construct laser-driven light source test setup



[2]K.A. Baker et. al. *Appl. Optics* **51**, 1086 (2012)
[3]E.J. Tremblay et. al. *Opt. Express* **20**, A964 (2012)
[4]V. Zagolla et. al. *Opt. Express* **20**, A924 (2012)

KEY RESULTS AND OUTCOMES





- Hybrid collection optic design: flat Petzval surface, sunlight collected over ±50° incidence at a geometric gain >150x with efficiency >95%.
- 1 collaborative manuscript in preparation, 1 award received (Giebink, DARPA Young Faculty Award)

NEXT MILESTONES

- Settle on a collection optic design that meets phase I performance target of 70% optical efficiency at 60x geometric gain for ±45° incidence angle
- Continue testing index-matching materials. Construct scattering element prototype and make initial efficiency measurements.
- Test feasibility of new self-adaptive scattering strategies.

➢ On track to achieve upcoming milestone M1.1 for simulated collection optic performance.

➢ Self-adaptive strategies being pursued are riskiest aspect of our effort at this stage, but carry high reward if successful. If found unsuitable, this risk is mitigated by falling back on an actively controlled scattering element.